Determining an optimal game strategy for a Business & IT serious game

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This paper addresses the optimization of decisions made within a serious game. The game (BITinline) is a serious game aimed at creating optimal Business and IT alignment by creating a multiyear IT policy that is in line with the strategic goal. Multiple simulations were run using the game logic to create this optimal policy. Results show that a policy can be created resulting in routes which are both fast and efficient. The current research furthermore shows that further research regarding game strategy optimization is needed.

Additional Key Words and Phrases: Business & IT, Serious Game, Business Strategy, Competing Value Model

1 INTRODUCTION

The importance of alignment between business strategy and IT strategy is widely recognized. While there exist some tools to help with obtaining this alignment, using serious games to do this is something that has not been explored much. Thus, the serious game called BITInline was created.

BITInLine is a serious game created by students and teachers of the University of Twente to help achieve optimal alignment between business strategy and business information technology (BIT)[8]. This alignment will further be referred to as BITA. Different companies will have different business strategies, depending amongst others on the sector and maturity of the organization. Some companies for example have a very flexible manner of working, while others have a business strategy where all processes are very specifically set and changes in this structure are hard to push through. In both cases, the business information technology should align with the business strategy to execute the business strategy in a successful way. This can be challenging[3].

To determine the level of BITA in a business, the competing value model[6] is used. Using this model, businesses can be given a score based on whether they are flexibile organizations or favour stability and if there is more of an internal or external focus. Based on these 2 measures, the business can be placed in one of the 4 quadrants of the competing value model. Each quadrant represents an ideal type strategy. The 4 ideal type strategies of the competing value model are the following: Cooperative, Adhocracy, Mecanistic and Market. Cooperative-minded businesses focus on teamwork and employee development. Adhocratic-minded businesses focus on innovation and are adapative and flexible. Mecanistic-minded businesses focus on stability, consistency and efficiency. Market-minded businesses focus on competition, profitability and secure customer bases.

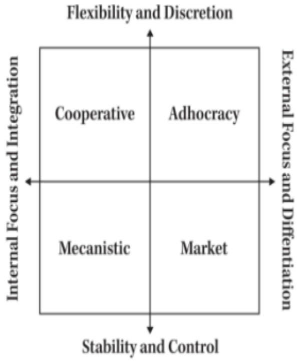

Fig. 1. The competing value model

In reality, businesses often do not use merely one of these strategies, but rather combine elements of different strategies of the competing value model[13].

The game start by dividing 100 points over the 4 strategies of the competing value model. The more points allocated to a quadrant, the more the business encorporates that strategy. By dividing the 100 points over the 4 strategies, a starting score is created. Next to the starting score, there is also an end score. The end score is the score which must be reached in order to achieve BITA. These scores can also be portrayed as a point on the competing value model, where the goal of the player is to move from the starting point to the end point. The level of BITA is expressed as the BITA score. A large distance between the starting point and end point will result in a low BITA score, while a small difference will result in a high BITA score. The maximum BITA score is 100. In this case, optimal BITA is reached.

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In BITInLine, the player can experiment with choosing different BIT practices and experience the long-term effect it has on the BITA. All BIT practices are based on one of the strategies of the competing values model and one of 6 IT strategy components[8]. For each combination of IT strategy component and ideal type strategy of the competing value model, 2 BIT practices are available to be chosen by the player. In total, there are 48 possible BIT practices to choose from . The game simulates multiple years of the business, with each turn representing 1 year. Thus, each turn the player chooses BIT practices that will be implemented that year. To make sure all parts of the business are covered, players are required to select at least 1 practice of each of the 6 IT strategy components for each turn.

In total, there are 8 BIT practices for each IT strategy component which players can choose to play as a move, resulting in a total of 48 BIT practices.

The effect of a move is based on a calculation model. Each BIT practice has a score for all 4 strategies of the competing value model. Based on the current score of the player and the score of the BIT practices chosen, the player will move towards a certain direction on the competing value model.

There are multiple challenges which have arisen when creating BITInline. As mentioned, each BIT practice has a score. However, these scores are not validated. Thus, the impact each BIT practice has is currently estimated. Another challenge is to determine the quality of a move.

There are 2 factors that determine the quality of a move. First of all, how fast a goal state is reached is considered, as the earlier an optimal alignment between business strategy and IT strategy is reached, the better. Second, the amount of BIT practices chosen throughout the game is considered. Achieving the goal state with having to implement as little BIT practices as possible is beneficiary to having to implement many BIT practices, due to the time and money needed in order to do this.

A final challenge is the occurrence of equifinality. Equifinality is when point can be reached from a starting point through multiple routes, each with similar performance. In the case of BITInline, this would mean that there are multiple different routes which can be taken to go from a start point to an end point which each reach the end point with the same quality of moves.

The challenges of finding the qualitative best move and determining equifinality will be the focus point of the research. Based on these challenges, the research goal will be determining the optimal IT policy for BITInline. The policy consists of 4 different aspects which are the following:

- The first part of the policy is what is the fastest route from a starting point to an end point. Players will see what practices they need to choose to get to the end point as quick as possible, and when the player arrives near the end point, to stay there and not sway away from it.
- Next to this, the most efficient route to the end point will be calculated. Efficiency is defined as “the ability to do something or produce something without wasting materials, time”.[20] Producing the same results with choosing less BIT practices to achieve this results will lead to a high efficiency. Implementing the BIT practices costs time and money, thus a route to the end goal where the lowest amount of practices possible are chosen can result in a cheaper option than the fastest route.
- After the fastest route and the most efficient route are determined, the next section of the policy will focus on the optimal balance between fastest route and most efficient route. An optimal policy would aim to both reach the end point as fast as possible and choose the least amount of practices along the way. A balance has to be found between these 2 factors, where both requirements can be met in the best way possible.
- Although there can be a theorical optimal route from a start to an end point, the way the calculation model is set up allows for multiple routes which differ substantially to be able to reach the same end point in around the same time. This principle is known as equifinality. In the case of BITInline, the ideal state of the business could be reached in multiple ways, with various BIT practices chosen throughout the years. Finding out what other routes there are and if these routes lead to similar results as the best possible route is valuable information for the player.

2 RELATED WORK

2.1 Change Management

In the current day and age, stability in an organization is rather seen as stagnation and as a form of lacking behind. Whereas organizations which are flexible and ever changing are seen as prosperous and as something positive. With a world that evolves constantly where new technologies are being invented at an exhilarating rate, not many people dare to predict what changes will happen in the upcoming year. Besides its unpredictability, it is theorized that the rate of change will increase at an exponential rate[5].

Much research has been done on change management within an organization[2, 4, 15], and more specifically on culture change. Cameron & Quinn ([6]) discuss the need for cultural change within an organization and consider an approach to applying change. A pattern can be found in how new organizations which have grown larger over time have experienced change. At first, organizations tend to lean to the adhocratic strategy in the competing values model, where there is no formal structure within the organization. As the organization develops, the culture starts to lean more towards a cooperative culture, with a sense of personal identification with the organization. After that there is a need of structure and hierarchy. This leads the culture of the organization to become mechanistic. Finally, the culture sways towards a mix between mechanistic and market, where achieving results becomes more important. While this pattern can be seen in many upcoming organizations, it is a lot harder to predict the change within matured and established organizations.

The amount of time it takes for an organization to implement change can vary drastically. Cameron & Quinn’s approach is based on the idea that it takes 5 years to make significant change within an organization’s culture. However, there are examples where this change is done in 6 months[11]. Since every organization is different and the amount of change that is done can vary drastically, it is not possible to say how long change will take. However, most occurrences of culture change have found to take no more than 5 years[1, 6].

2.2 Game Strategy Optimization

Trying to find the optimal strategy through the use of AI and other techniques has been a trending topic for many years now. One of the earlier examples and perhaps one of the most famous is IBM's Deep Blue[7]. Deep blue was a chess playing system which was the first computer to win a chess match against a world champion in 1997. Another case where a computer system was able to beat the best players in a game is DeepMind's AlphaGo, beating the world's best players in the Asian board game Go[19]. The first time AlphaGo beat a professional Go player was in 2015. As a continuation of AlphaGo, AlphaStar was created to play the video game StarCraft, with StarCraft being considerably more challenging to play than Go[12]. In 2019, AlphaStar achieved the rank of grandmaster, being ranked in the top 0.2% of StarCraft players.

These systems can be classified as artificial intelligence and make use of machine learning algorithms. AlphaGo used a type of artificial neural network called convolutional neural network to learn from human professional games[17]. While human games are used in the neural network to train the system how to become better, the system can reach a level of skill where the strategy of the best players are not replicated, but the system can create its own strategy. As Ko Ju-Yeon, a professional Go player, stated after AlphaGo beat Lee Sedol, one of the best Go players; "All but the very best Go players craft their style by imitating top players. AlphaGo seems to have totally original moves it creates itself,"[14].

By using matches of professional to learn a game, systems can learn what good strategies are. Afterwards, by letting the system play against (weaker versions of) itself, it can detect weaknesses in its own strategy and thus continuously improve it. This process is known as reinforcement learning[18].

2.3 Game Theory

Game theory is known as *"the study of the ways in which interacting choices of economic agents produce outcomes with respect to the preferences (or utilities) of those agents"*[16]. For BITInline, the possible choices the agent can make are all possible BIT practices it can choose to implement. The preferred outcome would be to achieve the highest possible BITA score each turn, where eventually the optimal BITA score of 100 is reached. Part of game theory is the solution to a game. A solution to a game is *"the optimal decisions of the players, ... , and the outcomes that may result from these decisions."*[**?**]. Through applying the optimal decisions, the desired state of an agent can generally be reached, unless the game is designed for the desired state to not be achievable.

As stated in the description of game theory, it revolves around a choice that has to be made. This choice impacts the current situation of the agent which respect to its desired state. Agents can be placed in a dilemma[10], where all options have both positive and negative consequences. A trade off has to be made, where a decision will result in a compromise in one part to excel in another part .

The use of game theory is used in more situations than just actual games. Concepts of game theory can be found in economics, politics and in biological phenomena[9]. For example, a concept often occurring in economics is the Nash equilibrium, where a state has been reached where the optimal outcome for each agent is where none of the agents deviate from their strategy.

3 PROBLEM STATEMENT

From the point of view of change management, the knowledge of an optimal route can give insight in what order change can be implemented in and what route has to be taken to reach optimal alignment. For instance, when an organization with a cooperative strategy wants to become more market-focused, the optimal policy can show if temporarily diverging to an adhocratic strategy can result in a faster route to the market strategy.

Besides this, BITInline has many game theory concepts which makes determining an optimal policy difficult. The optimal route does not have to be the only viable route. When determining a route, a trade off has to be made between how fast a goal state is reached and how effective it is reached. A route can be fast, but include the implementation of many BIT practices which costs both money and time. On the other side, a route can use little BIT practices which need implementing, but can take much time to reach the goal state. This, along with the occurrence of equifinality can result in many routes possibly being deemed as good, leading to difficulties in determining an optimal route.

3.1 Research Question

The problem statement leads to the following research question:

What is the optimal policy for a player playing BITInline, keeping in mind both the fastest and most efficient possibilities?

This research question can be answered with the following subquestions:

SQ1: What is the fastest way for a player playing BITInline to reach the designated end point from a chosen start point?

SQ2: What is the most efficient way for a player playing BITInline to reach the designated end point from a chosen start point?

SQ3: What is the optimal trade off between an efficient strategy and a fast strategy?

SQ4: To which extent does equifinality exist within BITInline?

4 METHODOLOGY

Each BIT practice has a score for all 4 of the strategies of the competing values model. The scores are based on how 100 points are divided over the 4 strategies. For example, a BIT practice that will lead a player towards the Mecanistic quadrant can have a score of [15, 10, 15, 60]. This array tells that the practice scores 15 out of 100 points for Cooperative, 10 out of 100 points for Adhocracy, 15 out of 100 points for Market and finally 60 out of 100 points for the Mecanistic strategy. An issue with the current state of BITInline is that there are only 4 possible scores a BIT practice can have, namely for each strategy of the competing values model 60 points for the strategy itself, 15 points for the 2 neighboring strategies and 10 point for to opposing strategy.

For this research, each practice is given a unique score. This is for the reason that the possibilities in finding the fastest route would be very limited if only 4 unique scores could be given to the BIT practices. Besides, in the future, BITInline will also incorporate unique scores for each practice, based on expert opinion. To give each BIT practice a unique score, a random number between 1.00 and -1.00 is added to the Cooperative and Adhocracy score. The scores of the opposing strategies of the competing value model, being the Market and Mecanistic strategy, will be changed in the same way as their opposing strategy but in the opposite direction. For example, an addition of 0.5 to the Cooperative score will result in a reduction of 0.5 to the Market score.

Before being able to start answering the research question and its sub-questions, the calculation model must be understood. The calculation model works in such a way that the score for each strategy of the competing value model affects all other scores when processing a move. For instance, how much the score for the Market strategy will be after a move is done does not only depend on the current market score and the market score of the chosen BIT practices. The score of the Cooperative, Mechanistic and Adhocracy strategies also impact this.

Prior to the start of this research, the calculation model was made using the macros functionality of excel. Due to the fact that there are better and faster options for doing large calculations and handling the data produced by the calculation model, the choice was made to rewrite the calculation model in python. After having done this and analyzing the functionality and behavior of the calculation model, a start could be made on answering the sub-questions of the research question.

4.1 Fastest Route (SQ1)

As mentioned in the introduction; there are restrictions as to what practices players can choose to play. All 48 BIT practices can be split up in 6 groups of 8 practices, with each group representing one of the 6 IT strategy components. When deciding what BIT practices to choose for each move, the player has the restriction that at least 1 BIT practice must be chosen from each of these 6 groups. Thus, the player must always choose at least 6 practices in total.

To calculate the fastest route to reach optimal alignment, a list will be made at first with each possible combination of BIT practices a player can choose to play, adhering to the requirements set. This list only has to be created once, since the possible combinations do not differ per situation in the game. As the BIT practices are split in 6 groups, there will be 6 lists of combinations, and not 1 list of combinations for all BIT practices.

For each group which represents 1 IT strategy component, the best combination of BIT practices is chosen. This is done by playing each combination as a move, with the current position being the starting point of the move. For each move, the player will receive a new BITA score. After having played all possible combinations within the group, the resulting BITA scores of all moves will be compared to each other. The combination resulting in the highest BITA score will be chosen as the best combination within the group.

This process is repeated for each group. However, with each following group, the best combination of the previous group is being passed on. Thus, for each new group, a best combination of BIT practices is chosen, keeping in mind that the BIT practices chosen in previous groups also have to be played. This can create a situation where for one of the groups a compromise has to be made to fix a sub-optimal choice of combination in a previous group.

Since the BIT practices do not have the same effect on the BITA score per group, going through the groups one by one in a fixed order will likely not result in the best possible move a player can play. Thus, in order to get closer to what the optimal combination of BIT practices is for each group, the process will be repeated for every order the 6 groups can be placed in. After a best possible move, with a move being a list of BIT practices to be implemented consisting of the best combinations of all 6 groups, has been chosen for each order the groups can be placed in, the moves will be compared to each other based on the new BITA score of the player when the move is played. The move with the highest BITA score will be selected as the best move that can be played.

This is repeated for each turn of the game. By repeatedly doing this, the player will either reach the end point or come as close as possible to the end point. Due to the nature of the calculation model, points with extreme scores cannot be reached. This phenomenon is further discussed in the results section.

4.2 Most Efficient Route (SQ2)

To determine the most efficient way of reaching an end point, a similar method is used as the method to answer SQ1. A list of combinations is used and each combination is tried as a move, to in the end find be fastest move. However, for answering SQ2, not the fastest move, but the most efficient move must be determined.

To do this, extra restrictions are set on what combination of moves are possible. By limiting the combinations to only have 1,2 or 3 BIT practices for each IT strategy component, less BIT practices have to be implemented and thus there is higher efficiency.

4.3 Balance between Fast and Efficient (SQ3)

After the fastest routes and the most efficient routes are determined, the optimal balance can be determined between the 2. The performance of possible combinations for each level of efficiency will be portrayed in a table. There will be an analysis on all combination sizes, ranging from 1 practice per IT strategy component to having the possibility to choose from all 8 per component. In the final option, the player has the choice to choose all practices if they wish. However, the restriction still applies that at least 1 practice must be chosen per IT strategy component. Thus, not all combinations of practices are available.

By determining what BITA score can be reached for each combination size, an overview can be made what the best balancie is between a fast strategy and an efficient strategy.

4.4 Equifinality (SQ4)

When answering the previous sub questions, only the move resulting in the highest BITA score was considered. However, in the case equifinality takes place, a move that at first seems like a worse

Fig. 2. Graph on the route when focussing on optimal BITA gain

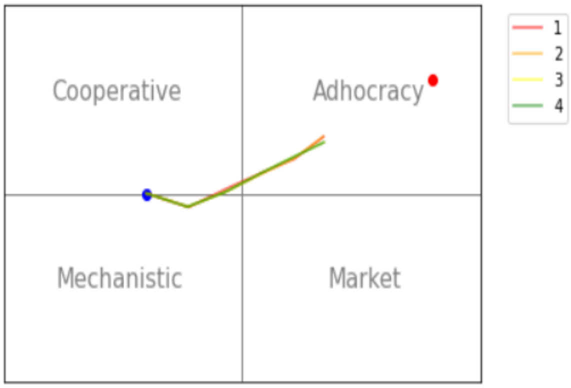


Fig. 3. Graph on the route when focussing on efficiency

move and does not result in the highest BITA score possible can position the player to be able to reach the end point easier. Thus, when determining if there are strong alternatives to the fastest route, more options will be taken into consideration.

In order to determine whether equifinality occurs and, if this is the case, what other routes could be found, the following method is used. From a starting point, the 10 moves resulting in the highest BITA score will be calculated. These calculations will be done in the same way as described in the methodology for answering SQ1. Of these moves, the best and worst options are chosen to be played as moves. Applying these moves will result in 2 new points. Next, starting from these 2 new points, this process will be repeated, resulting in 4 new points. By doing this repeatedly, multiple routes will be created. Even routes that look like sub-optimal routes in the beginning are possible to be lined up correctly with multiple “bad” moves in the beginning to eventually reach the end point faster than the route that takes the move with the highest BITA score each turn.

If equifinality occurs, multiple routes will arise which are vastly different. For example. If a starting point is located in the Cooperative quadrant and an end point is in the Market quadrant, equifinality would occur if 2 viable routes were determined of which one would reach the Market quadrant by going through the Adhocracy quadrant first, while the other would reach the Market quadrant by going through the Mechanistic quadrant first. While these routes have the same starting point and end point, the points that are reached in between differ.

5 RESULTS

To visualize the results of the sub-questions, a graph is made which is similar to the competing values model, as can be seen in figures 2 and 3. In this graph, each quadrant represents one of the 4 strategies in the competing values model. A player’s current score can be indicated through a point on the graph, where the position of the player depends on the score for each strategy. For example, a high score for the Market strategy will cause the player to be placed in the market quadrant, with a maximum score for the Market strategy (100) being placed in the bottom right corner. In the graph, a starting point is indicated through a blue dot and the point which represents optimal alignment when reached is indicated through a red dot. To keep continuity, the same starting point and point with optimal alignment are being used throughout the results section. The starting point has the following score:

- Cooperative: 30
- Adhocracy: 20
- Market: 10
- Mechanistic: 40

The end point, representing optimal alignment, has the following score:

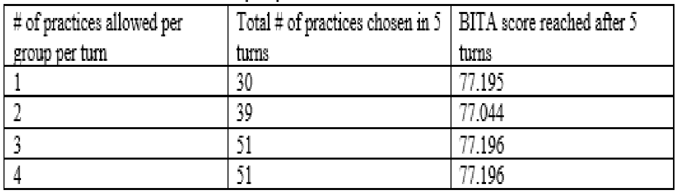
- Cooperative: 10
- Adhocracy: 70
- Market: 20
- Mechanistic: 0

Only for answering SQ4, a different starting point was used. This was done because points which are located on opposite quadrants of the competing value model have more different routes it could theoretically take. For answering SQ4, the starting point has the following score:

- Cooperative: 20
- Adhocracy: 0
- Market: 10
- Mechanistic: 70

5.1 Fastest Route (SQ1)

By calculating the option which increases the BITA score the most for each turn, a route is determined. Due to the significant time it takes to calculate a move, the result shown is the route which took 5 turns/years. This could theoretically go on for as many turns as one would want. However, eventually the route would merely circle around the end point continuously. An example of the route the algorithm chooses is shown in figure 2. The green line shows the progress of the player, starting at the blue dot and playing all moves until eventually the line reaches the point with the highest BITA score possible. Every green dot represents the position of the player at the start of a turn.



# of practices allowed per group per turn	Total # of practices chosen in 5 turns	BITA score reached after 5 turns
1	30	77.195
2	39	77.044
3	51	77.196
4	51	77.196

Fig. 4. Table on balance between speed and efficiency

5.2 Most Efficient Route (SQ2)

The optimal efficiency is reached when only 1 BIT practice can be chosen per IT strategy component, thus having a move consisting of 6 different practices. Although this is efficient, the possibilities are very limited. Too see the effect of limiting the amount of practices that can be chosen, a graph is made as can be seen in figure 3.

The numbers on the right indicate how many BIT practices were allowed to be chosen for each IT strategy component. Logically, the more practices a player has the opportunity to choose from, the more influence the player has on the direction it will be moving. The biggest difference in route is between the green line and the orange line. The results between 2 and 4 choices are significant. Although there are significantly more options to choose, the route found from taking at most 3 combinations for each IT strategy component was already deemed the fastest option, as there are no changes between line number 3 and line number 4 in chosen BIT practices. Why this is the case is further discussed in the conclusion and discussion section.

5.3 Balance between Fast and Efficient (SQ3)

The table in figure 4 shows the relation between the amount of practices which can be chosen per turn and the highest BITA score which is reached through the algorithm made described in the methodology section. While the number of practices chosen rises, the obtained BITA score does not improve drastically. Rather, the obtained BITA score even decrease when 2 practices are allowed to be chosen per group instead of 1. This is due to the nature of the algorithm and its limitations. Due to the immense computing power needed to calculate the outcome of each possible move, a compromise must be made where an optimal route is can be approached in the best way possible. This allows for situations like the one shown in the table where being limited in the amount of BIT practice one can choose results in a better performance. This is further elaborated and discussed in the conclusion.

5.4 Equifinality (SQ4)

By using the approach mentioned in the methodology, multiple routes are created which are heading towards the end point. The results of this can be found in figure 5. 9 turns are being simulated resulting in a total of 512 separate routes being created. All lines drawn in the graph have the same color and thickness. The reason as to why some lines seem thicker than other is due to the fact that these are multiple lines which are very close to each other, making it seem like one thick line.

Fig. 5. Graph on equifinality

5.5 Extreme Values

From applying the methodology to different starting points and end points, it was found that scores with extreme values could not be reached. If one of the 4 strategies of the competing values model would have an end score over 75, it is not able to reach that point with the current allocation of scores to BIT practices. If BIT practices were to have more extreme scores as well, these points could possibly be reached. Although not all points can currently be reached, this does align with theory on change management. In organizations it is the case that a strategy is not solely based on one of the 4 strategies of the competing values model, but rather a combination of multiple strategies[13].

5.6 Other approaches

The methods explained in the methodology where not the first methods that were thought of to answer the research (sub)questions. There were other methods to answer the research (sub)questions, however, there were issues which caused these methods not suitable to be applied for this research project. These methods will be explained in this section.

At first, a method to determine an optimal route was to go through all possible moves a player can play and see which move resulted in the highest BITA score. There are 48 possible BIT practices for players to choose from. A move consists of a combination of these 48 BIT practices. This results in a total of 2.81475E+14 possible moves a player can play. Due to the limited amount of time and computing capacity available in this research project, handling such large amounts of data is simply not possible. An idea had to be thought of to work around this problem. The first proposed solution was that of using clusters. By grouping moves which had similar effect, less computational resources were needed. However, the problem occurred that grouping such a large amount of moves into cluster would still take too long. Another solution was to split the 48 moves in groups of 8, based on the IT strategy components. For each component, the best move within that group would be calculated. Afterwards the best moves of all components would be combined to 1 move that covered all components. This is the method that eventually was used.

6 CONCLUSION AND DISCUSSION

The conclusion is set up in the following way: First, the sub questions will be addressed one by one, giving a conclusion for that sub question and discussing the results. After the sub questions have been discussed, the research question will be addressed, with an overall conclusion and discussion.

6.1 Fastest Route (SQ1)

The algorithm made can find a route to a designated point which is close to the fastest route. However, it can not be said that the objectively best route will always be found. This is due to 2 reasons. First of all, not every possible move is evaluated. Due to the large amount of combinations, this is not possible. Secondly, the route is being created step by step. This means that each turn is seen as separate from other turns. If a route is created as a whole, a move in the beginning that seems weak could turn out to set up a route which is much faster. For example, if 2 moves were evaluated as moves that would be played in succession, a faster route could be found. This is due to the fact that the route is evaluated by the outcome after both moves have been played. Since the route is created step by step, there will be an evaluation of what the best move is for each turn. Evaluating multiple moves was not a possibility due to the amount of possible combinations that arise when doing this and the lack of computational power to process all these combinations.

6.2 Most Efficient Route (SQ2)

To answer the second sub question, an algorithm was made which did the same steps as the algorithm used to answer the first sub question. However, these steps were done for different situations where the number of BIT practices which could be chosen for each IT strategy component changed per situation. From the results, it can be seen that different routes are taken when more BIT practices can be chosen. However, after a certain number of BIT practices that can be chosen has been reached, the route the algorithm produces does not change anymore. This can be explained. There are 4 different scores a BIT practice can have, with each of the 4 scores leaning heavily towards one of the 4 strategies of the competing value model. When determining a route to go to a point placed in one of the quadrants of the competing value model, the algorithm will especially need BIT practices leaning towards that quadrant, while sometimes also needing BIT practices of the neighboring quadrants to adjust its route slightly to more accurately move towards to end point. Thus only 6 of 8 BIT practices of each group are useful.

Due to the limited options of possible moves when choosing 1 practice, it is possible that the algorithm gets stuck in a place and can not reach the end goal. Since there is no combination of practices that gets the player closer, it will move back and forth between 2 positions. As the algorithm can only calculate 1 move at a time and not a full route, situations like this occur.

6.3 Balance between Fast and Efficient (SQ3)

From looking at the results for the third sub question, it can be concluded that having the choice of more BIT practices does not result in a fastest route towards an end point. The BITA score which is reached after 5 moves barely improves, or even declines as can be seen by the change in going from 1 BIT practice per group to 2 BIT practices per group. There is a reason as to why this occurs. Similar to how in the algorithm used to answer SQ1, a move is not evaluated as a full move, but is evaluated per group. By combining all best combinations chosen within the 6 groups, a move is determined. However, it can be the case that there are better moves. If moves were evaluated as a full move, all possible combinations which can form a move must be evaluated, and as explained before, this is not possible to do within the time of the research. Since it is not possible to find the objectively best move, cases like to one occurring in the results happen where although for the first row the combination of BIT practices one can play is very limited, still a better solution is found compared to the situation in the second row, where more combinations of BIT practices are possible.

6.4 Equifinality (SQ4)

The results show that there are multiple routes which lead to the direction of the end point. However, the differences in these routes are not significant. Each route follows roughly the same route, where a straight line across the diagonal of the graph is being followed. There are 2 reasons as to why this occurs and why within this research project it is not possible to achieve results which could better evaluate to which extent equifinality exists.

First, the algorithm made focusses purely on determining a best move and repeats this until a route is found. The route which the algorithm determines is the best route is purely chosen by after every move choosing the best move in the new position. This does not allow for much diversion when finding good routes. There was an attempt to solve this problem through not taking the best 2 options at each point, but rather the best option and the 10th best option. Analyzing the behavior of the algorithm, it was seen that the best 8 moves the algorithm came up with were often the same move, but with different BIT practices. As many BIT practices have the same score, this did not affect the outcome of a move drastically. The 10th best move found often moves in a different direction. Hence it was chosen to use the best move and the 10th best move. However, this still did not cause routes which where significantly different to be found.

Next to this, a similar problem occurred as in the other sub questions. There simply was not enough computational power available to be able to find multiple routes. For the method currently used, each route branches into 2 new routes. However, if it were possible for it to branch into more routes without the time needed to do this becoming to much, this could lead to result which could better evaluate to which extent equifinality exists.

6.5 Research Question

Overall a policy was made which could produce the following:

- What a fast route is to reach the point of a (near) optimal BITA score, if this point is not an extreme point and is reachable with the current scores given to BIT practices.
- What a fast route is to reach the point of a (near) optimal BITA score with set restrictions which allow for a limited size for combinations of BIT practices to be chosen.

- An overview of what BITA score can by achieved depending on what size of combinations of BIT practices is allowed to be chosen.
- Routes other than the route determined in answering SQ1 which also can reach an end point fast.

The main limiting point which caused the routes which were found to not be the optimal routes was the fact that there was not enough time to do calculations which could result in finding optimal routes. Due to this, multiple approaches were thought of to be able to calculate a route which is as good as possible, but none of the approaches could lead to an optimal route to be found. For each situation, there is the possibility that the route that is produced can be better, both in terms of reaching a higher BITA score or being more efficient. How better results could be achieved is discussed in the future work section.

7 FUTURE WORK

As mentioned in the results section, an option to get closer to being able to calculate the theoretical best move is to use clusters. Also the possibility of using AI to determine the best move is something that can be explored. After time has been spent training a model to find a good strategy, less computing power will eventually be needed to determine an optimal strategy.

Next to this, the sub question regarding equifinality can be improved further. For this research project, the method to find other routes with similar performance is not the most effective and is unable to provide routes which are significantly different to the routes determined in answering sub question 1 to 3. Besides, even if some other routes were found, there are no guarantees that all other routes with similar performance will be found. Thus, other methods could be researched to developed a way to accurately and reliably find these different routes.

By solving these 2 issues, a better policy can be formulated, leading to the problem statement being closer to solved. To compute an ultimate solution to the problem statement, an objectively best route for each situation has to be found. If the objectively best route were to be determined through going through all possible options and checking which one is the best, it would take way too long for normal computer systems to calculate this. There are a total of 2.81475E+14 moves a player can play in a single turn. Even if it were possible to calculate the best move with this amount of moves, a long term strategy would need a route of multiple moves. While there are other methods to get close to what the objectively best move could be, these can likely not assure that the best move will be found.

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